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ORIGINAL PAPER

Species composition and minimum sampling area of a riparian mixed broadleaved-Korean pine forest in Changbai Mountain Nature Reserve

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Abstract: Riparian areas are unique although often small component of the overall watershed landscape. The structure of riparian forests along Erdaobai River on the north slope of Changbai Mountain were investigated by using field data collected from eight sampling transects perpendicular to the Erdaobai River channel. Two kinds of species-area saturation curves were used to examine the relationship between species number and minimum sampling area. The results showed that riparian gymnosperms accounted for a high proportion of all gymnosperms in the Changbai Mountain Nature Reserve while riparian ferns and angiosperms accounted for a relatively low proportion. The average minimum sampling areas of riparian forest that included 60%, 80%, and 90% of the community species pool were about 85, 185, and 328 m^2, respectively; while those for nonriparian forest were about 275, 390, and 514 m^2, correspondingly.

Key words: mixed broadleaved-Korean pine forest; minimum sampling area; ecosystem management; Changbai Mountain

Introduction

A riparian zone, a type of landscape representation of the aquatic-terrestrial ecotone, is an area where direct interaction occurs between land and water systems. Riparian vegetation serves a variety of significant functions in ecology, aesthetics, and social-economy (Chen 1996; Deng et al. 2001). Riparian forest provides habitat for wildlife and is the source of coarse woody debris and nutrients for streams. Also, riparian forest influences the micro-climate around streams and rivers, maintains water quality, provides places for human recreation, and serves as the base for development of agriculture, forestry, stockbreeding, and fisheries (Naiman & Decamps 1997).

In recent years, riparian ecology has been studied by many researchers. In China prior to 1990, research on riparian areas focused primarily on floodplain vegetation as a component of wetland research. Studies on relationships between plant communities and habitats from the perspective of riparian areas began at the turn of the century. For example, a comprehensive examination of distribution patterns of riparian communities was carried out in the Three Gorges Area (Jiang et al. 2000). Jiang (2001) studied the patterns and functions of riparian vegetation along the Xiangxi River in the Shennongjia area. At the same time, some studies on the structure and pattern of riparian communities were also conducted at Changbai Mountain (Deng et al. 2001; Deng et al. 2002; Deng et al. 2003).

The Changbai Mountain Nature Reserve was established in 1960 and was designated a Man in the Biosphere Reserve in 1980. Mixed broadleaved-Korean pine forest is distributed below an altitude of 1100 m in the Changbai Mountain area. This well protected natural forest provide an ideal opportunity to conduct forest research. Before 2000, most of the research in this region focused on terrestrial ecosystems and less attention was given to riparian ecosystems. We based our study on the proposition that knowledge of the structure and function of riparian zones in this area will be important to the conservation of regional biodiversity.

Erdaobai River is located on the south slope of Changbai Mountain Nature Reserve and originates from Heaven Lake (Fig. 1). It is the upper source of Songhua River, one of the most important rivers in northeast China. Thus, the management of Erdaobai River and its riparian areas is necessary for regional sustainable development. The objective of the present study was to

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investigate the species structure and minimum sampling area in riparian plant communities along the Erdaobai River.

Materials and methods

Sampling design and process

In 2008, eight 8m×96m sampling belts perpendicular to the Erdaobai River channel were established in the mixed broad-leaved-Korean pine forest at elevations of 750, 800, 850, 900, 950, 1 000, 1 050, and 1 100 m (Fig. 1). All sampling belts were placed on the same side of the river, which was primarily the east side. For each sampling belt, the first 20 m from the river was divided into 40 sampling quadrats earch 2 m × 2 m, while the remaining 76 m of sampling belt length was divided into 38 quadrats of 4 m × 4 m each (Fig. 2).

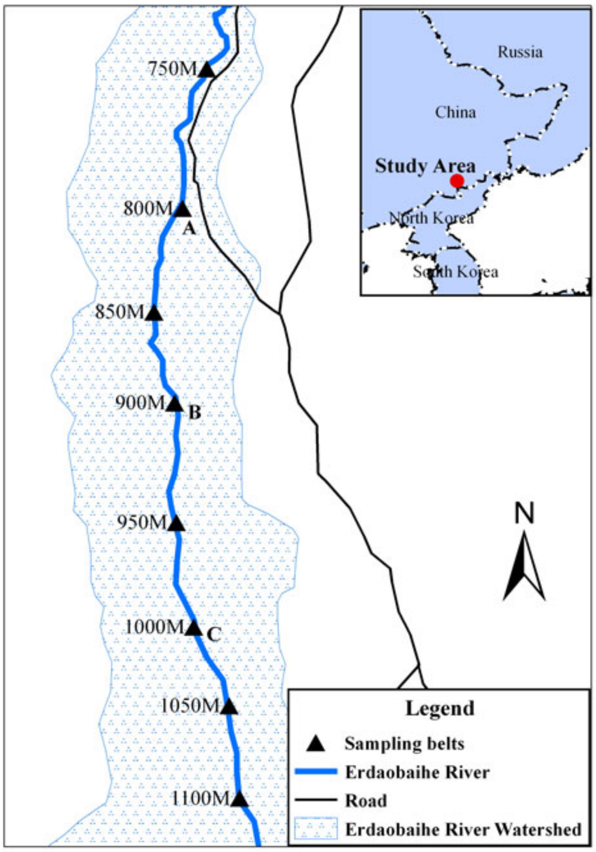

Fig. 1 The study area and sampling belt location

In each small quadrat, all trees were identified to species and measured for height and diameter at breast height. For shrubs and herbs we recorded abundance, coverage percent, and average height of each species. Soil samples were collected every 4 m along sampling belts to measure pH, water content, and nutrient content.

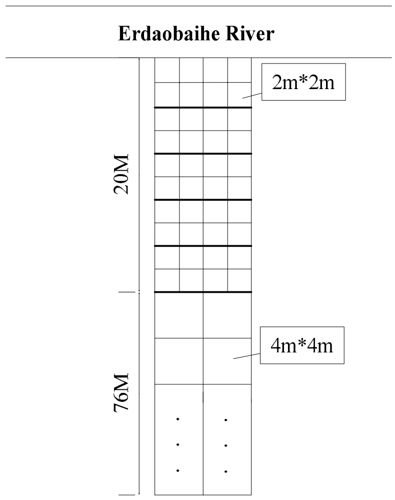

Fig. 2 Vegetation belt and its plot design in riparian zone

Minimum sampling area

The minimum sampling area, the area just large enough to give an accurate account of the species composition of a species assemblage (Weinberg 1978), is a fundamental concept of plant and animal ecology for recording a certain proportion of species within a community (Taylor 2002). Three sampling belts at altitudes of 800 m, 900 m, and 1 000 m were selected to study the minimum sampling area for riparian communities. Two kinds of species-area saturation curves (Srivastava 1999; Niu et al. 2009) were used to examine the relationship between species number and minimum sampling area.

$$S = \frac{aA}{1 + bA} \tag{1}$$

$$S = \frac{c}{1 + ae^{-bA}} \tag{2}$$

where S is the species number, A is the minimum sampling area, and a, b and c are parameters.

Results

Species composition of riparian plant communities

In total 288 vascular plant species belonging to 169 genera and 68 families were recorded in the investigated riparian communities (Table 1). Among these we recorded 26 fern species of 16 genera and 11 families and 262 spermatophyte species of 153 genera and 57 families. Among spermatophytes, there were nine gymnosperm species of six genera and three families, and 253 angiosperm species of 147 genera and 54 families. Among angiosperms, there were 212 dicotyledonous species of 118 genera and 45 families and 41 monocotyledonous species of 29 genera and nine families (Table 1).

Table 1. Vascular plant species in the riparian zone in Erdaobai River catchments

Vascular plant species		Riparian zone			Changbai Mountain Nature Reserve		
		Family	Genus	Species	Family	Genus	Species
Fern		11	16	26	23	40	127
Seed plant	Gymnosperm	3	6	9	3	8	15
	Angiosperm						
	Dicotyledon	45	118	212	88	372	970
	Monocotyledon	9	29	41	18	116	289
Total		68	169	288	132	536	1401

With respect to all vascular flora in Changbai Mountain Nature Reserve (Qian 1989; Fu et al. 1995), families, genera, and species of vascular plants recorded during our sampling in the riparian zone accounted for 52%, 32%, and 21% of the total, respectively. Riparian gymnosperms accounted for a high proportion of all gymnosperms in Changbai Mountain Nature Reserve: 100% at the family level, and 75% and 60% at genus and species level, respectively. In contrast, riparian ferns and angiosperms comprised smaller proportions of vascular flora in the Changbai Mountain Nature Reserve; families, genera and species of fern all represented less than 51% of the nature reserve totals.

Minimum sampling area of riparian plant community

The statistical results of species richness in three sections of the sampling belt, *S_1: 0–32 m closest to the river, S_2: 32–64 m from the river, and S_3: 64–96 m from the river*, are shown in Table 2. The number of species in different layers of S_1 exceeded those in both S_2 and S_3. Species richness did not differ between sections S_2 and S_3.

The minimum sampling areas needed to include 60% of trees, shrubs, herbs, and total plant species in the riparian zone were 64, 111, 81, and 85 m^2, respectively. Similarly,the minimum sampling areas needed to include 80% of these species were 152, 225 178, and 184 m^2, respectively, while the average minimum sampling area was about 185 m^2. To include 90% of these species required sampling over 267 m^2, 404, 315, and 325 m^2, respectively (Table. 3).

Table 2. Species number counted in sections of riparian community and comparison of species between riparian community and non-riparian community

Elevation(m)	Layer	Riparian community							Non-riparian community	Gap
		Number of species			Percentage (%)			Riparian		
		S_1	S_2	S_3	S_1	S_2	S_3			
800	Trees	24	18	18	100.0	75.0	75.0	24	20	4
800	Shrubs	25	20	20	80.6	64.5	64.5	31	15	16
800	Herbs	30	24	20	83.3	66.7	55.6	36	42	-6
800	Communities	79	62	58	86.8	68.1	63.7	91	77	14
900	Trees	17	16	15	68.0	64.0	60.0	25	14	11
900	Shrubs	19	17	13	70.4	63.0	48.1	27	15	12
900	Herbs	44	30	31	86.3	58.8	60.8	51	32	19
900	Communities	80	63	59	77.7	61.2	57.3	103	61	42
1000	Trees	21	12	13	95.5	54.5	59.1	22	17	5
1000	Shrubs	19	15	15	95.0	75.0	75.0	20	14	6
1000	Herbs	49	40	43	80.3	65.6	70.5	61	45	16
1000	Communities	89	67	71	86.4	65.0	68.9	103	76	27

Table 3. Minimum sampling areas of communities and different layers

Elevation (m)	Equation	Proportional factor (*P*)											
		0.6				0.8				0.9			
		Trees	Shrubs	Herbs	Communities	Trees	Shrubs	Herbs	Communities	Trees	Shrubs	Herbs	Communities
800	1	36	83	50	56	95	222	133	148	214	500	300	333
800	2	65	108	92	86	117	166	181	147	159	214	255	198
900	1	71	125	47	68	190	333	125	182	429	750	281	409
900	2	141	217	83	131	304	357	158	254	439	473	220	355
1000	1	22	50	79	58	58	133	211	154	130	300	474	346
1000	2	48	80	138	111	147	137	260	220	228	185	361	310
Average		64	111	81	85	152	225	178	184	267	404	315	325

Discussion

Comparing vascular plant species in the riparian zone with those in Changbai Mountain Nature Reserve as a whole, we found that riparian gymnosperms accounted for a high proportion of all gymnosperms, while riparian ferns and angiosperms accounted for a relatively low proportion. This may be due to the impacts of seasonal flooding; which might suppress intolerant shrubs and especially herbs. Most gymnosperms in riparian areas at the

Changbai Mountain Nature Reserve are mature trees, so, even with losses due to flooding, enough trees survive to maintain high proportional presentation. However, most angiosperms are shrubs or herbs and ferns are herbs, all of which are more readily impacted by flooding (Naiman & Decamps 1997).

Plant communities in riparian areas of Changbai Mountain Nature Reserve were generally those found in the temperate climatic zone. There were 20 families of temperate distribution species and all were distributed along riparian areas of the Erdaobai River. These results suggest that the special hydrologic conditions and micro-terrain environments of riparian areas stabilized temperature changes and maintained local features of zonal vegetation (Chen 1996).

The range of minimum sampling area in temperate forest was suggested to be 200–500 m^2 Mueller-Dombois et al. (1974). Hao (2000) concluded that the minimum sampling areas for non-riparian communities at the same altitude as our Changbai Mountain site should be 275 m^2, 390 m^2, and 514 m^2 to include 60%, 80%, and 90%, respectively, of total plant species. Thus, the minimum sampling area for riparian communities as derived in this study is less than that for non-riparian communities as described in previous studies, which might be due to the special habitat and plant distribution patterns in riparian areas.

Comparison of riparian communities and non-riparian communities suggests that the former were generally more species rich (Table 2). The reason for higher species richness of riparian communities might be related to the higher intensity and frequency of flooding, changes of soil or terrain, the impacts and interferences of upland habitat on riparian areas, and plant migration (Naiman et al. 1993).

Conclusion

It is important to conserve biodiversity for the sake of our own curiosity and aesthetic appreciation. The establishment of nature reserves is a primary means of biodiversity conservation. As the study of biological diversity intensifies in China, assessment and adjustment of the priorities of protected areas is important. The results of this study showed that the riparian zone along the Erdaobai River is one of most biodiverse habitats in Changbai Mountain Nature Reserve. This demonstrates that the riparian zone in biodiversity conservation has an important role. Riparian ecology should receive more attention and proactive riparian management plans should be implemented for biodiversity protection.

A reasonable minimum sampling area is important to manage and conserve biodiversity and to protect the functions of riparian zone. When considering advisable minimum sampling area, the economic effects should be considered so that it can be implemented successfully.

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